Lasers in Surgery and Medicine 22:219–222 (1998)

Treating Bullous Lung Disease With Holmium YAG Laser in Conjunction With Fibrin Glue and DEXON™ Mesh

Shizuka Kaseda, MD,[1]* Teruhiro Aoki, MD,[1] Nanae Hangai, MD,[1] Tadashi Omoto, MD,[2] Shuzo Yamamoto, MD,[2] and Hitoshi Sugiura, MD[3]

[1]*Departments of Thoracic Surgery, Saiseikai Kanagawa-ken Hospital, Yokohama 221, Japan*

[2]*Department of Surgery Saiseikai Kanagawa-ken Hospital, Yokohama 221, Japan*

[3]*Department of Pathology, Clinical Research Laboratories, Kawasaki City, Ida Hospital Kawasaki 221, Japan*

Background and Objective: **Holmium YAG (Ho:YAG) laser energy is highly absorbed by water, and this property is useful to uniformly ablate pulmonary bullae. The current study summarizes the data of a 39-month follow-up of patients treated for bullae with a Ho:YAG laser.**

Study Design/Materials and Methods: **We used a Ho:YAG laser from August 1994 to April 1997 to treat small pulmonary bullae in 50 patients. For the first five patients, Ho:YAG laser ablation was followed by resection for histological assessment. In the next six patients, fibrin glue was applied following bullae ablation with the Ho:YAG laser. In all subsequent patients, a DEXON™ (polyglycolic acid) mesh patch soaked in fibrin glue was employed after ablation.**

Results: **From the six patients receiving only the fibrin glue following laser ablation, delayed pneumothorax developed in one patient. In the subsequent 39 patients patched with DEXON™ mesh soaked in fibrin glue, none encountered delayed pneumothorax.**

Conclusion: **The combined use of fibrin glue and Dexon™ mesh with the Ho:YAG laser may be an effective technique for treating bullous lung disease. Lasers Surg. Med. 22:219–222, 1998.**

© 1998 Wiley-Liss, Inc.

Key words: ablation; pulmonary bullae; DEXON™ Mesh, fibrin glue, Holmium:YAG laser

INTRODUCTION

The Holmium YAG (Ho:YAG) laser delivers invisible light in the infrared region, at a wavelength of 2.1 μm, and is 100 times better absorbed in water than the Nd:YAG laser, which is already widely used in medicine. The energy delivered from the Ho:YAG laser, transmitted via an optic fiber, uniformly penetrates tissue to a depth of within 0.5 mm regardless of tissue pigments [1]. Having discovered these characteristics to be particularly suitable for ablating bullae, which are comprised primarily of nonpigmented tissue, we have introduced the Ho:YAG laser in the treatment of pulmonary bullae of less than 3 cm in diameter. The ablated sites were further treated with a DEXON™ (polyglycolic acid) mesh patch soaked in fibrin glue. This report describes the technique and discusses our findings.

*Correspondence to: Shizuka Kaseda, Department of Thoracic Surgery, Saiseikai Kanagawa-ken Hospital, 6-6 Tomiya-cho, Kanagawa-ku, Yokohama 221, Japan.

Accepted 30 December 1997

© 1998 Wiley-Liss, Inc.

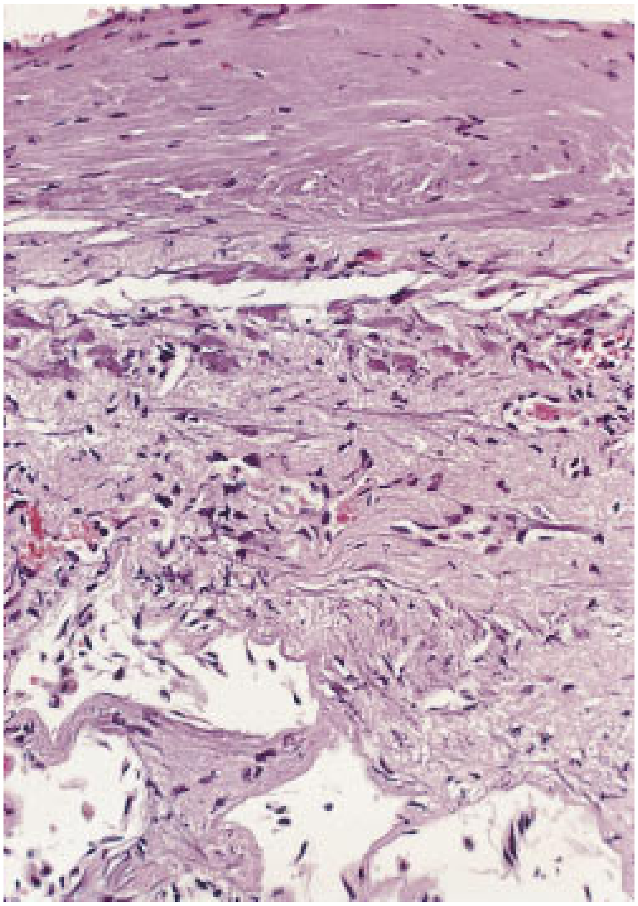

Fig. 1. Thermal damage caused by Ho:YAG laser energy is recognized to a depth of from 0.3 to 0.5 mm in the bullous wall (hematoxylin and eosin, ×100).

PATIENTS AND METHODS

Fifty patients with bullous lung disease undergoing thoracoscopic surgery between August 1994 and April 1997 were included in the study.

All bullae of less than 3 cm in diameter were treated with Ho:YAG laser delivered through an optic fiber from a distance of 2–3 cm ranging in energy from 0.5 to 0.8 joules and in frequency from 5 to 10 pulses per second. Each bulla was treated in one treatment session until thoracoscopic observation confirmed whitening of the bulla, which amounted to a total energy ranging from 130 to 4,770 joules (mean ± SD: 1,427 ± 1,307).

In the first five patients, the pulmonary bullae were resected after laser ablation in order to confirm the effect of the Ho:YAG laser (Fig. 1). In the next six patients, bullae ablated with Ho:YAG laser were not resected, and fibrin glue (Beriplast®, Behringwerke AG, Marburg, Germany) alone was applied to the treated sites. Finally, in the remaining 39 patients, 9-cm^2 patches of DEXON™ mesh (Davis & Geck, Inc., Pearl River, NY) soaked in fibrin glue solution were employed on the ablated sites to prevent delayed pneumothorax.

RESULTS

Histological examination of the resected bullae revealed uniform tissue degeneration extending to a depth of from 0.3 to 0.5 mm; however, there was no evidence of damage done to the normal lung tissue below this level (Fig. 1). Among the six patients receiving fibrin glue alone following laser treatment, one (16.7%) developed delayed pneumothorax 6 weeks after the operation. On the other hand, in the 39 patients receiving the DEXON™ mesh patch soaked in fibrin glue solution, none has shown any evidence of this complication during 27 months of follow-up.

DISCUSSION

Although the Nd:YAG laser is most widely used today in surgery of the respiratory tract [2–5], its energy is poorly absorbed by nonpigmented tissue. When used to treat highly nonpigmented tissue such as bullae, Nd:YAG laser energy is only poorly absorbed by the treatment site while possibly causing irreversible damage to the underlying normal lung tissue. Furthermore, previous studies have reported a higher incidence of delayed pneumothorax in patients treated with laser than those with endostapler alone [6]. These drawbacks have limited the indication for Nd:YAG laser surgery.

On the contrary, since the Ho:YAG laser has a very high affinity for water, it is uniformly absorbed by any water-bearing tissue regardless of its pigment [1]. Because the tissue irradiated with Ho:YAG laser energy shrinks evenly up to 0.3–0.5 mm in depth, the Ho:YAG laser is very useful in treatment such as shrinkage of bullous walls. However, there have not been any studies to date reporting the use of the Ho:YAG laser or recommending the application of fibrin glue and DEXON™ mesh for treating pulmonary bullae, and we believe the present study is the first to attempt the application of the Ho:YAG laser in combination with fibrin glue and DEXON™ mesh in treating bullae.

Fibrin glue is a physiological adhesive consisting of fibrinogen and thrombin solutions; upon

combining the two components, the thrombin is responsible for converting the fibrinogen into fibrin. In surgery of the respiratory tract, fibrin adhesive is often used to prevent air leakage after lung resection [7,8]. However, due to its weak adhesive property, the glue easily detaches from the treated site. On the other hand, Morikawa et al. demonstrated in their experimental study using dogs that an absorbent polyglycolic acid mesh (DEXON™ mesh) patch possesses a much greater adhesive strength than the fibrinogen and thrombin mixture alone [9]. In our series of patients, one patient treated with the Ho:YAG laser and fibrin glue alone developed delayed pneumothorax 6 weeks after surgery, indicating that the use of the Ho:YAG laser in conjunction with an adhesive only, such as fibrin glue, increases the risk of developing delayed pneumothorax. Our clinical results also revealed that the use of fibrin glue in combination with the DEXON™ mesh patch following holmium YAG laser application prevents the occurrence of this complication.

Commercial fibrin glue for hemostats is available in Europe, Canada, and Japan. However, the United States Food and Drug Administration (FDA) has been reluctant to grant product licenses because of concerns about virus transmission from human blood products, immune reactions against components in bovine blood products, and a lack of prospective studies on product efficacy. Nevertheless, surgeons in United States use “home-made” fibrin glues without restriction, and demand for cryoprecipitated human fibrinogen, the main component of the glue, is on the increase.

An autologous fibrin glue is one way to avoid the risks of virus infections and unwanted immune responses. However, these autologous fibrin glues are actually semi-autologous and are not free from foreign proteins because they are co-administered with pooled plasma-derived bovine or human thrombin, and with bovine aprotinin which acts a fibrinolytic stabilizer. A number of viral inactivation techniques have been developed to reduce the risks of using pooled sources of human fibrinogen and human thrombin in fibrin glue. Some companies are developing a physiological fibrin adhesive set in the United States, and commercial fibrin glues will be approved by the FDA in the very near future. If this is realized there will be no need to use autologous fibrin glue even in the United States.

While the use of the endostapler has recently been recommended for resection of bullous lesions of the lung, particularly in emphysema [6], it is necessary to use a large number of endostaplers which are, in Japan, about four times as expensive as in the United States. This is the reason why we refrain from using endostaplers. The endostapler is also difficult to apply correctly in certain regions of the lung, such as hilar lesions, because of technical difficulty or the high feasibility of injuring large vessels.

The most significant advantage of the Ho:YAG laser is that it can evenly ablate 0.3 to 0.5 mm of tissue regardless of the tissue pigment. This property of the Ho:YAG laser has proven to be useful in other specialties in addition to thoracic surgery, such as urology [10,11], orthopedics [12,13], general gastroenterological surgery [14,15], otorhinology [16], and gynecology [17]. In the future, more noninvasive surgery will be possible with the Ho:YAG laser in conjunction with the development of various new biocompatible repair materials.

REFERENCES

1. Trost D, Zacherl A, Smith M. Surgical laser properties and their tissue interaction. In: Smith MFW, McElveen JT, eds. “Neurological Surgery of the Ear.” St. Louis: Mosby Year Book, Inc., 1992, pp 131–162.
2. Brenner M, Kayaleh RA, Milne EN, et al. Thoracoscopic laser ablation of pulmonary bullae. J Thorac Cardiovasc Surg 1994; 107:883–890.
3. Fleisher AG, Evans KG, Nelems B, et al. Effect of routine fibrin glue use on the duration of air leaks after lobectomy. Ann Thorac Surg 1990; 49:133–134.
4. Keenan RJ, Landreneau RJ, Hazelrigg SR, et al. Video-assisted thoracic surgical resection with the neodymium:yttrium-aluminum-garnet laser. J Thorac Cardiovasc Surg 1995; 110:363–367.
5. Moghissi K, Neville D. Effect of the non-contact mode of YAG laser on pulmonary tissues and its comparison with electrodithermy: an anatomo-pathological study. Lasers Med Sci 1988; 17:17–23.
6. McKenna R, Brenner M, Gelb AF, et al. A randomized, prospective trial of stapled lung reduction versus laser bullectomy for diffuse emphysema. J Thorac Cardiovasc Surg 1996; 111:317–322.
7. Mouritzen C, Dromer M, Keinecke HO. The effect of fibrin gluing to seal bronchial and alveolar leakages after pulmonary resections and decortications. Eur J Cardiothorac Surg 1993; 7:75–80.
8. Thetter O. Fibrin adhesive and its application in thoracic surgery. Thorac Cardiovasc Surg 1981; 29:290–292.
9. Morikawa T. Fundamental analysis of efficacy of new methods for sealing the cut surface of lung using fibrin glue and absorbable mesh. Haiganshujutsushugi 1995; 8:38–45.
10. Gilling PJ, Cass CB, Malcolm AR, et al. Combination holmium and Nd:YAG laser ablation of the prostate: initial clinical experience. J Endourol 1995; 9:151–153.

11. Johnson DE. Use of the Holmium:YAG (Ho:YAG) laser for treatment of superficial bladder carcinoma. Lasers Surg Med 1994; 14:213–218.
12. Gary S. The use of the holmium laser in arthroscopic surgery. Semin Orthopedics 1992; 17:102–116.
13. Owens P. Holmium laser arthroscopy opens new frontier for orthopedics. Laser Nursing 1991; 5:97–103.
14. Johnson JP, Oz MC, Chuck RS, et al. Comparison of methods for transcatheter fragmentation of gallstones. Surg Endosc 1989; 3:7–10.
15. Spindel ML, Moslem A, Bhatia KS, et al. Comparison of holmium and flashlamp pumped dye laser for use in lithotripsy of biliary calculi. Lasers Surg Med 1992; 12: 482–489.
16. Metson R. Holmium:YAG Laser endoscopic sinus surgery: a randomized, controlled study. Laryngoscope 1996; 106(Suppl 77):1–18.
17. Duffy S, Davis M, Sharp F, et al. Preliminary observation of holmium:YAG laser tissue interaction using human uterus. Lasers Surg Med 1992; 12:147–152.